

03/14/00



JCS42 U.S. PTO

THE ASSISTANT COMMISSIONER OF PATENTS
Washington, D.C. 20231

DOCKET NUMBER: AUS990869US1
MARCH 9, 2000

A

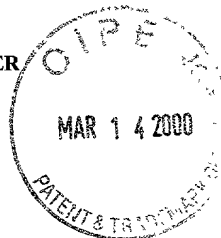
JCS598 U.S. PTO
09/524901
03/14/00

Sir:

Transmitted herewith for filing is the Patent Application of:

Inventor: JIENMING QI, ET AL.

For: A HIGH SPEED, STATIC DIGITAL MULTIPLEXER



Enclosed are:

- ☒ Patent Specification and Executed Declaration
- ☒ 3 sheets of drawing(s).
- ☒ An assignment of the invention to International Business Machines Corporation (includes Recordation Form Cover Sheet).
- ☐ A certified copy of a application.
- ☐ Information Disclosure Statement, PTO 1449 and copies of references.

The filing fee has been calculated as shown below:

For	Number Filed	Number Extra	Rate	Fee
Basic Fee				\$690.00
Total Claims	17 - 20	0	x 18 =	\$
Indep. Claims	3 - 3	0	x 78 =	\$
0 MULTIPLE DEPENDENT CLAIM PRESENTED			x 270 =	\$
TOTAL				\$690.00

- ☒ Please charge IBM Corporation Deposit Account No. 09-0447 in the amount of \$690.00 A duplicate copy of this sheet is enclosed.
- ☒ The Commissioner is hereby authorized to charge payment of the following fees associated with this communication or credit any overpayment to IBM Corporation Deposit Account 09-0447. A duplicate copy of this sheet is enclosed.
- ☒ Any additional filing fees required under 37 CFR §1.16.
- ☒ Any patent application processing fees under 37 CFR §1.17.

Respectfully submitted,

By Eustace P. Isidore

Eustace P. Isidore
Registered with Limited Recognition - see attached
FELSMAN, BRADLEY, VADEN,
GUNTER & DILLON, LLP
Suite 350 Lakewood on the Park
7600B North Capital of Texas Highway
Austin, Texas 78731
Telephone (512) 343-6116

A HIGH SPEED, STATIC DIGITAL MULTIPLEXER

BACKGROUND OF THE INVENTION

1. Technical Field:

The present invention relates in general to digital circuits and in particular to a digital multiplexer. Still more particularly, the present invention relates to an improved design of a static digital multiplexer.

2. Description of the Related Art:

A multiplexer (MUX) is an electronic device, which is capable of accepting more than one input signal simultaneously and chooses one (or more) of the input signals as an output signal in response to the state of one or more select input. Conventional multiplexers are typically designed utilizing a combination of transistors from within the family of metal-oxide-semiconductor field-effect transistor (MOSFETs). Traditional static complementary MOS (CMOS) multiplexers have larger overall surface area and are typically relatively slow. Currently, the more common MUX designs being utilized include static pass gate and transmission gate multiplexers. Both of these MUXes have found extensive use in microprocessor designs due to their high density and relatively low power performance. They also provide higher speed than traditional static complementary MOS (CMOS) multiplexers.

A three input, static pass gate multiplexer (PG-MUX) is depicted in **Figure 1**. PG-MUX 100 is usually built

with N-type MOSFETs (NFETs) 101 because they have larger current driving capability than PFETs. Each input 109 of PG-MUX 100 is coupled to an inline inverter 111, whose output is coupled to the drain of NFET 101. A
5 corresponding select signal 113 is connected to the gate of NFET 101. The source of each NFET 101 is coupled to a muxnode 108. Muxnode 108 is coupled to the drain of PFET 107 and to a second inverter 103 in turn coupled to output 115. NFET 101 in PG-MUX 100 is a passive device;
10 therefore, second inverter 103 is interposed between muxnode 108 and output 115 to yield sufficient current driving capability for output 115.

In operation, the total delay of PG-MUX 100 is the sum of the delays of an input inverter 111, a pass
15 transistor (NFET 101), and second inverter 103. As is well known in the art, PG-MUX 100 is effective for passing a high input signal (i.e., a "1").

One major big drawback with a PG-MUX is that it cannot effectively and/or quickly pass a logic low input
20 signal (i.e., a "0"). This is because the voltage at muxnode 108 is not the full power supply voltage, V_{DD} , of PFET 107 but rather is reduced by the value of the threshold voltage (V_t) of PFET 107 (i.e., $V_{DD}-V_t$). In order to pass a good logic "1" (i.e., inverted input
25 "0"), a "half-latch" 105 is utilized to pull-up PFET 107 to V_{DD} . A typical half-latch 105 is implemented with PFET 107 whose gate is coupled in a feedback loop around

second inverter 103. Utilization of half-latch 105 when passing a "1" followed by a "0" results in a significant switching penalty. By enabling a faster pass of a "1" with half-latch 105 a subsequent pass of a "0" is slowed down. This switching delay between "1" and "0" occurs because half-latch 105 continues to charge muxnode 108 until muxnode 108 is discharged to "0" and produces a "1" via inverter 103 to disable PFET 107. Therefore, a significant time is taken for the next input signal "1" to pass through as the half-latch 105 attempts to keep up the power at muxnode 108 after passing a logic "1" (i.e., inverted input signal 0), while the input is attempting to keep the power down. This "fight" causes additional current to be drawn, which leads to extra power dissipation and slower overall speeds.

A conventional three-input transmission gate multiplexer (TG-MUX) is illustrated in **Figure 2**. Each input 209 of TG-MUX 200 is connected to inline inverter 211, whose output is coupled to the drain of NFET 201 and source of PFET 207. NFET 201 and PFET 207 are connected in parallel, source to drain. A corresponding select signal 213 is connected to the gate of NFET 201, while the complement of select signal 206 is connected to the gate of PFET 207. Complement of select signal 206 is generated by passing select signal 213 through second inverter 204. The outputs of the parallel branches of NFET 201 and PFET 207 are coupled together at muxnode 208. Muxnode 208 is connected to third inverter 203, which inverts the signal to produce output 115.

Unlike a PG-MUX, TG-MUX 200 does not utilize a half-latch to pass a good "0" or good "1". However, TG-MUX 200 is not necessarily faster than a PG-MUX, because TG-MUX uses additional parallel PFET 207, which is weaker than NFETs and adds extra delays due to a larger capacitance. In the design of TG-MUX 200, select signal 213 and its complement signal 206 have to be applied, and thus extra circuitry (i.e., second inverter 204) is required to generate complement signals 206. Utilizing extra circuitry 204 prevents select signal 213 and complement signal 206 from arriving at the same time due to the delays associated with second inverter 204. The "under-lapping" of select signal 213 and complement signal 206 leads to longer "open" time of the gates of the transistors 201 and 207 respectively, which leads to cross DC currents through the input data paths. Such currents in turn result in speed degradation and extra power dissipation.

Improving the operation of the conventional designs of multiplexers has proven to be difficult. In particular, no major improvement in speed and low power applications has occurred recently.

The present invention recognizes that it would be desirable and beneficial to have a multiplexer circuit with improved speed performance over the traditional MUX circuits. It would further be desirable to provide a multiplexer circuit which operates with low power dissipation. A MUX design which incorporates both improved speed and power dissipation, while overcoming

[illegible]

SUMMARY OF THE INVENTION

A high speed static multiplexer is disclosed comprising: (1) a plurality of data inputs and at least one select input; (2) an output; (3) a high voltage rail and a low voltage rail; (4) a pull-up circuit coupled between the output and the high voltage rail and further coupled to receive the data inputs and the select input so that the pull-up circuit generates a first logic state at the output in response to the selected data input having that first logic state; (5) and a pull-down circuit coupled between the output and the low voltage rail and further coupled to receive the data inputs and the select input, so that the pull-down circuit generates a second logic state at the output in response to the selected data input having that second logic state.

In a preferred embodiment, three N-type transistors are utilized in each of at least two sets of transistors corresponding to each data input. The data input is coupled to an inverter, which inverts the input data. The output of the inverter is coupled to the drain of the first transistor and to the gate of the third transistor. The pull-down circuit includes the second and third transistors, which are connected in series and enable a fast pull-down of the output during selection of a low input data. The select input circuit is coupled to the gate of the first transistor and the gate of the second transistor. The pull up circuit includes a P-type transistor, with its gate connected to the source of the first transistor. The output is coupled to the drain of the second transistor and is also operatively coupled to the drain of the P-type transistor. Operation of the P-type transistor allows selection of the output to occur

[illegible]

The above as well as additional objects, features, and advantages of the present invention will become apparent in the following detailed written description.

BRIEF DESCRIPTION OF THE DRAWINGS

The novel features believed characteristic of the invention are set forth in the appended claims. The invention itself however, as well as a preferred mode of use, further objects and advantages thereof, will best be understood by reference to the following detailed description of an illustrative embodiment when read in conjunction with the accompanying drawings, wherein:

Figure 1 is a block diagram of a prior art, three-input, pass gate multiplexer;

Figure 2 is a block diagram of a prior art, three-input, transmission gate multiplexer;

Figure 3 is a block diagram of a three-input, high speed, static multiplexer according to one preferred embodiment of the present invention; and

Figure 4 is a block diagram of a bi-level, nine-input, high speed static multiplexer according to another preferred embodiment of the present invention.

DETAILED DESCRIPTION OF ILLUSTRATIVE EMBODIMENT

This invention provides a new design of a static multiplexer, referred to herein as the high-speed, static multiplexer (HSS-MUX), which substantially reduces or eliminates the problems inherent with conventional pass gate and transmission gate multiplexers. For example, HSS-MUX eliminates the fight condition in the PG-MUX described previously. The HSS-MUX of the present invention demonstrates higher speed performance and operates with low-power dissipation.

Figure 3 illustrates a three-input implementation of a preferred embodiment of the HSS-MUX of the present invention. HSS-MUX 300 includes one set of NFETs for each data input 309A-309C. Each set of NFETs includes three NFETs, first NFETs 301A-301C, second NFETs 302A-302C, and third NFETs 303A-303C. Each data input 309A-309C of HSS-MUX 300 is coupled to a respective in-line inverter 311, which is in turn coupled to the drain of a respective one of first NFETs 301A-301C and to the gate of a respective one of third NFETs 303A-303C. Corresponding select signals 313A-313C are connected to the gate of first NFETs 301A-301C and to the gate of second NFETs 302A-302C. Second NFETs 302A-302C and third NFETs 303A-303C are coupled source-to-drain (i.e., connected in series). The source of third NFET 303A-303C is connected to ground 304.

The sources of first NFETs 301A-301C are coupled

together at muxnode 308. Muxnode 308 is coupled to the gate of PFET 307, and the source of PFET 307 is connected to power supply voltage (V_{DD}) 310. The drains of second NFETs 302A-302C are coupled together with the drain of PFET 307 at output 315 of HSS-MUX 300.

Data input may be either high or low (i.e., a logic 1 or 0). Select signals may be on (1) or off (0). The efficient operation of HSS-MUX 300 requires that select signals 313A-313C are orthogonal, i.e., only one select signal may be "on" at any time. This constraint is the same for a pass gate or transmission gate multiplexer. Those skilled in the art will appreciate that an overlapping of "1"s with select signals may lead to longer delay and greater power dissipation. Also, an under-lapping of "1"s with select signals can cause temporary floating state at muxnode 308 and the output 315. Therefore, in one embodiment, full latch structures are incorporated at the possible floating nets to improve noise tolerance.

A. Selected Input is Logic High

In operation, when input 309A receives a logic high input (1) and select signal 313A is on, the value of input 309A is inverted (1 to 0) by inverter 311. Select signal 313 turns on first NFET 301A and second NFET 302A. Inverted input (0) is received at the gate of third NFET 303A and turns off third NFET 303A. Inverted input also is sent to the drain of first NFET 301A and passes a "0" to muxnode 308 and ultimately to gate of PFET 307, which

turns on. Shutting off third NFET **303A** effectively shuts off second NFET **302A**, which is connected in series, as current flow to ground **304** is inhibited. Output **315** is high "1".

5

Thus, output **315** is pulled up with PFET **307**, which is fed a good "0" by the muxnode **308** when a selected data input is "1". Under this condition, second and third NFETs **302A** and **303A** are disabled and there is no steady state current flowing through them.

10

B. Selected Input is Logic Low

If, input **309A** is receives a logic low input (0) and select signal **313** is on, the value of input **309A** is inverted (0 to 1) by inverter **311**. Select signal **313** turns off first NFET **301A** and second NFET **302A**. Inverted input (1) is received at the gate of third NFET **303A** and turns on third NFET **303A**. Inverted input also is sent to the drain of first NFET **301A**, which passes a "1" to muxnode **308** and ultimately to gate of PFET **307**, which turns off. Output **315** is directly pulled down to low (0) by second and third NFETs **302A** and **303A** as current flows to ground **304**. This pull-down of output **315** leads to a faster operation.

15

20

During operation of HSS-MUX **300**, second and third NFET **302A** and **303A** are utilized to pull down the output to logic low when a particular one of data inputs **309A-309C** is low and a corresponding one of select signals

25

313A-313C is on. This feature leads to a faster pull-down characteristics of HSS-MUX 300 compared to the conventional PG-MUX and/or TG-MUX. In a conventional PG-MUX or TG-MUX, more effort is required to produce a "0" at the output from a data input value of "1." First, the muxnode needs to be charged high, which is a slow process. Second, the "1" at the muxnode is inverted by the following inverter to produce a "0" at the output, resulting in additional time loss.

Another advantage which is recognized with HSS-MUX 300 is its low power dissipation. PFET 307, can be turned off by a weak "1" and thus requires a relatively low voltage swing for switching. The signal swing at muxnode 308 ranges between zero and the difference between the drain voltage and the threshold voltage ($V_{DD} - V_t$) of PFET 307. This reduced signal swing, causes muxnode 308 to be pulled down to "low" faster than with a full signal swing (i.e., zero to V_{DD}). Thus, overall power dissipation is reduced. Unlike a PG-MUX, no half-latch is required to pull-up muxnode 308 to full V_{DD} 310. Additionally, different from a conventional PG-MUX or TG-MUX, muxnode 308 of HSS-MUX 300 is coupled to the gate of PFET 307 rather than an output inverter. The load at muxnode 308 is thus substantially reduced and overall speed of HSS-MUX 300 is improved.

According to the embodiment of Figure 3, the orthogonal select signals 313 are applied to first NFETs 301A-301C and second NFETs 302A-302C. This allows second and third NFETs 302A-302C and 303A-303C to be isolated

and enable better speed and noise tolerance. In one preferred embodiment, each pair of second and third NFETs **302A-303A**, **302B-303B**, **302C-303C** may be tapered (i.e., second NFETs **302A-302C** are made with smaller transistors than third NFETs **303A-303C**). The capacitance seen at the output node is that of second NFET **302A-302C**, and therefore the output node capacitance is reduced, resulting in a higher speed.

HSS-MUX **300** is capable of directly driving other static logic or some other load through the PFET pull-up device and second and third NFET pull-down functionality. For example, HSS-MUX can directly feed an inverter, a NAND gate, a NOR gate, or another multiplexer.

Figure 4 illustrates a bi-level nine-input HSS-MUX according to another preferred design of the present invention. Two levels of HSS-MUXes are illustrated with the first level comprising of 3-three input HSS-MUXes **400**, **410**, **420**. The outputs **415A-415C** of MUXes **400**, **410** and **420** at the first level are coupled to the inputs **409D** of second level MUX **430**. This configuration utilizes several single HSS-MUXes to create an expandable multi-way MUX **450**. Unlike HSS-MUX **300** of **Figure 3**, HSS-MUXes utilized to create expandable multi-way MUX **450** do not include an inverter coupled to the inputs **409A-409D**. No inverter is required since the outputs **415A-415C** at the first level, which are inverted, are in turn inverted at the second level to yield the corrected output **415D**. Each HSS-MUX thus produces an output **415A-415D**, which is inverted compared to the corresponding selected data

input among data inputs 409A-409D. Thus, a number of N-input HSS-MUXes may be utilized to create a bi-level NxM-input multiplexer, where M is equal to or less than N. For example, by directly feeding the outputs of 8 eight-input HSS-MUXes to the data input of another 8 input HSS-MUX, a 64-input HSS-MUX may be constructed, which yields a positive logic output. The number of levels of MUXes may be further expanded to yield an even more complex design.

The MUX of the present invention was compared with a conventional pass gate and static gate multiplexers during a series of circuit simulations. Optimized 8-input multiplexers were utilized. Two different types of transistors within the MUXs were tested, bulk silicon and silicon on insulator (SOI). The simulations were performed using the same input drivers, same output loading to each MUX, and for both data-gated (i.e., the data arrived after the select signal) and select-signal gated (i.e., the select signal arrived after the data) conditions. All MUXs were individually optimized, and the worse case delay scenario analyzed. The simulation results are presented below in Table I. As explained below, the HSS-MUX of the present invention achieved substantial speed improvements over conventional pass gate and transmission gate multiplexers.

Table I

	8S SOI	8S SOI	8S Bulk	8S Bulk
	select-gated	data-gated	select-gated	data-gated
TG-MUX	19%	15%	25%	22%
PG-MUX	8%	8%	18%	19%

The first test simulated CMOS SOI technology. As illustrated in Table I, the HSS-MUX demonstrated a worst case delay improvement of 19% and 8% over a transmission gate multiplexer and a pass gate multiplexer, respectively. The second test, which simulated CMOS bulk technology resulted in a worst case delay improvement by HSS-MUX over the conventional MUXes of 25% and 19%, respectively.

The HSS-MUX exhibits improved speed performance over the conventional multiplexer designs. HSS-MUX utilizes a PFET; however, no keeper function is required. Also, the HSS-MUX exhibits a small signal swing which results in significant power saving. Due to the low power feature, i.e., because the PFET shuts off for relative voltages, which is less than a full value of V_{DD} , HSS-MUX may save power over conventional MUXes.

While the invention has been particularly shown and described with reference to a preferred embodiment, it will be understood by those skilled in the art that various changes in form and detail may be made therein without departing from the spirit and scope of the invention. For example, although the invention has been described with specific reference to a MOSFET transistor technology, the invention is capable of being implemented utilizing other types of transistor technology, such as MESFETs. Transistors are thus presented in the claims with three nodes, a control node, a first data node and a second data node. In the preferred embodiment, control node refers to the gate of both N-type and P-type transistor, first data node refers to the drain of N-type

[illegible]

CLAIMS:

What is claimed is:

1 1. A high speed static multiplexer comprising:
2 a plurality of data inputs and at least one select
3 input;
4 an output;
5 a high voltage rail and a low voltage rail;
6 a pull-up circuit coupled between said output and
7 said high voltage rail and further coupled to said
8 plurality of data inputs and said at least one select
9 input, wherein said pull-up circuit generates a first
10 logic state at said output in response to a selected data
11 input having said first logic state; and
12 a pull-down circuit coupled between said output and
13 said low voltage rail and further coupled to receive said
14 plurality of data inputs and said at least one select
15 input, wherein said pull-down circuit generates a second
16 logic state at said output in response to a selected data
17 input having said second logic state.

1 2. The high speed static multiplexer of Claim 1,
2 wherein said pull-up circuit comprises:
3 a P-type transistor having a control node, and a
4 first and second data node, coupled at said first data
5 node to said output and at said second data node to said
6 high voltage rail, wherein said P-type transistor
7 exhibits signal swings less than said high voltage rail;
8 a plurality of N-type transistors, each having a control
9 node, and a first and second data node, wherein said
10 second data node of each of said plurality of N-type
11 transistors is coupled to a control node of said P-type
12 transistor, said first data node of each of said

13 plurality of N-type transistors is coupled to a
14 respective one of said plurality of data inputs, and said
15 control node of each of said plurality of N-type
16 transistors is coupled to said at least one select input.

1 3. The high speed static multiplexer of Claim 2,
2 wherein said pull-down circuit comprises:
3 a plurality of sets of N-type transistors, wherein
4 each set includes a first and second transistor coupled
5 in series, and further wherein said second transistor is
6 coupled at its second data node to said low voltage rail
7 and at its control node to one of said at plurality of
8 data inputs, and wherein said first transistor is further
9 coupled at its control node to said at least one select
10 input and at its first data node to said first data node
11 of said P-type transistor.

1 4. The high speed static multiplexer of Claim 1,
2 wherein each of said plurality of inputs are coupled to a
3 respective inverter.

1 5. A high-speed static multiplexer comprising:
2 at least two data inputs circuits that each receive
3 a respective data input;
4 at least one select input, wherein each of said at
5 least one select input receives a respective select
6 signal;
7 an output; and
8 a plurality of transistors operationally coupled
9 between said at least two data input circuits and said
10 output, wherein said plurality of transistors each have a
11 control node and a first and second data node and wherein
12 said plurality of transistors are controlled by both data
13 inputs and select signals to select of one of said data
14 inputs to yield said output.

1 6. The high speed static multiplexer of Claim 5,
2 wherein said plurality of transistors include a P-type
3 transistor and a plurality of sets of first, second, and
4 third N-type transistors for each of said at least two
5 data inputs.

1 7. The high-speed static multiplexer of Claim 6,
2 wherein each of said at least two data input circuits
3 includes an in-line inverter for inverting said
4 respective data input to produce an inverted input.

1 8. The high speed static multiplexer of Claim 7,
2 wherein:
3 each of said at least two data input circuits is
4 coupled to a control node of said third N-type transistor
5 and to a first data node of said first N-type transistor;
6 and

7 said at least one select signal input is coupled to
8 a control node of said first N-type transistor and to a
9 control node of said second N-type transistor;

1 9. The high speed static multiplexer of Claim 8,
2 wherein further:

3 a second data node of said first N-type transistor
4 is connected to a control node of said P-type transistor;

5 a second data node of said P-type transistor is
6 connected to a power supply (V_{DD}); and

7 a first data node of said P-type transistor is
8 connected to said output.

1 10. The high speed static multiplexer of Claim 9,
2 wherein further:

3 a second data node of said third N-type transistor
4 is connected to ground;

5 a first data node of said third N-type transistor is
6 coupled to a second data node of said second N-type
7 transistor; and

8 a first data node of said second N-type transistor
9 is coupled to said first data node of said P-type
10 transistor at said output.

1 11. The high speed static multiplexer of claim 6,
2 wherein said P-type transistor has an on state and off
3 state and wherein a voltage differential at said control
4 node to change between said on and off states is less
5 than the voltage differential between a high voltage
6 applied at a second data node of said P-type transistor
7 and a low voltage applied at a second data node of said
 third N-type transistor.

1 12. The high speed static multiplexer of claim 6,
2 wherein said plurality of transistors are field effect
 transistors (FETs).

12. The high speed static multiplexer of claim 6,
wherein said plurality of transistors are field effect
transistors (FETs).

1 13. A multi-level high-speed static multiplexer
2 comprising:

3 a plurality of connected levels of high speed static
4 multiplexers, wherein each of said high speed
5 multiplexers comprises:

6 a plurality of data inputs and at least one
7 select input;

8 an output;

9 a high voltage rail and a low voltage rail;

10 a pull-up circuit coupled between said output
11 and said high voltage rail and further coupled to
12 said plurality of data inputs and said at least one
13 select input, wherein said pull-up circuit generates
14 a first logic state at said output in response to a
15 selected data input having said first logic state;
16 and

17 a pull-down circuit coupled between said output
18 and said low voltage rail and further coupled to
19 said plurality of data inputs and said at least one
20 select input, wherein said pull-down circuit
21 generates a second logic state at said output in
22 response to a selected data input having said second
23 logic state; and

24 wherein each of said outputs at a first level
25 of said plurality of levels is coupled to one of said
26 plurality of data inputs of said high speed static
27 multiplexers at a next level of said plurality of levels,
28 wherein a multiplicative-input multiplexer is realized
29 having $N \times M$ possible outputs, where N is a number of data
30 inputs at said first level and M is the number of data
31 inputs at the next level.

1 14. The multi-level high speed static multiplexer of
2 Claim 13, wherein said plurality of levels includes more
3 than two levels with a final level having a single high
4 speed static multiplexer, and wherein each of said
5 outputs of a given level is fed into at least one input
6 at a next level until said final level.

1 15. The multi-level high speed static multiplexer
2 circuit of Claim 14, wherein each even number of levels
3 yields a corrected output and each odd number of level
4 yields an inverted output.

1 16. The multi-level high speed static multiplexer of
2 Claim 15, further comprising an inverter coupled to each
3 of said data inputs at said first level when said number
4 of levels is odd.

1 17. The multi-level high speed static multiplexer of
2 Claim 15, further comprising an inverter coupled to said
3 output at said final level when said number of levels is
4 odd.

A HIGH SPEED, STATIC DIGITAL MULTIPLEXER**ABSTRACT OF THE DISCLOSURE**

A high speed static multiplexer comprising: (1) a plurality of data inputs and at least one select input; (2) an output; (3) a high voltage rail and a low voltage rail; (4) a pull-up circuit coupled between the output and the high voltage rail and further coupled to receive the data inputs and the select input so that the pull-up circuit generates a first logic state at the output in response to the selected data input having that first logic state; (5) and a pull-down circuit coupled between the output and the low voltage rail and further coupled to receive the data inputs and the select input, so that the pull-down circuit generates a second logic state at the output in response to the selected data input having that second logic state.

FIGURE 1

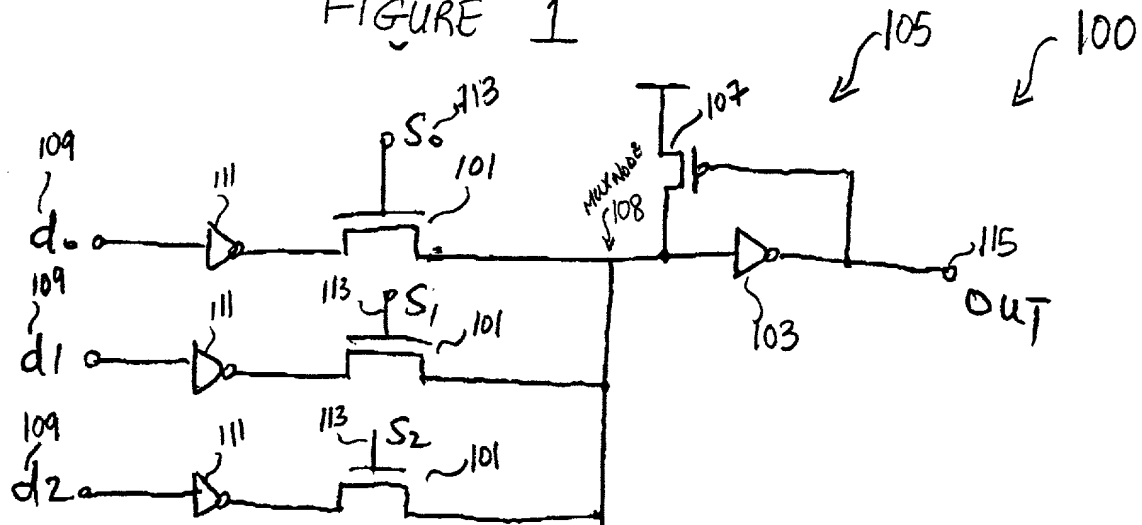
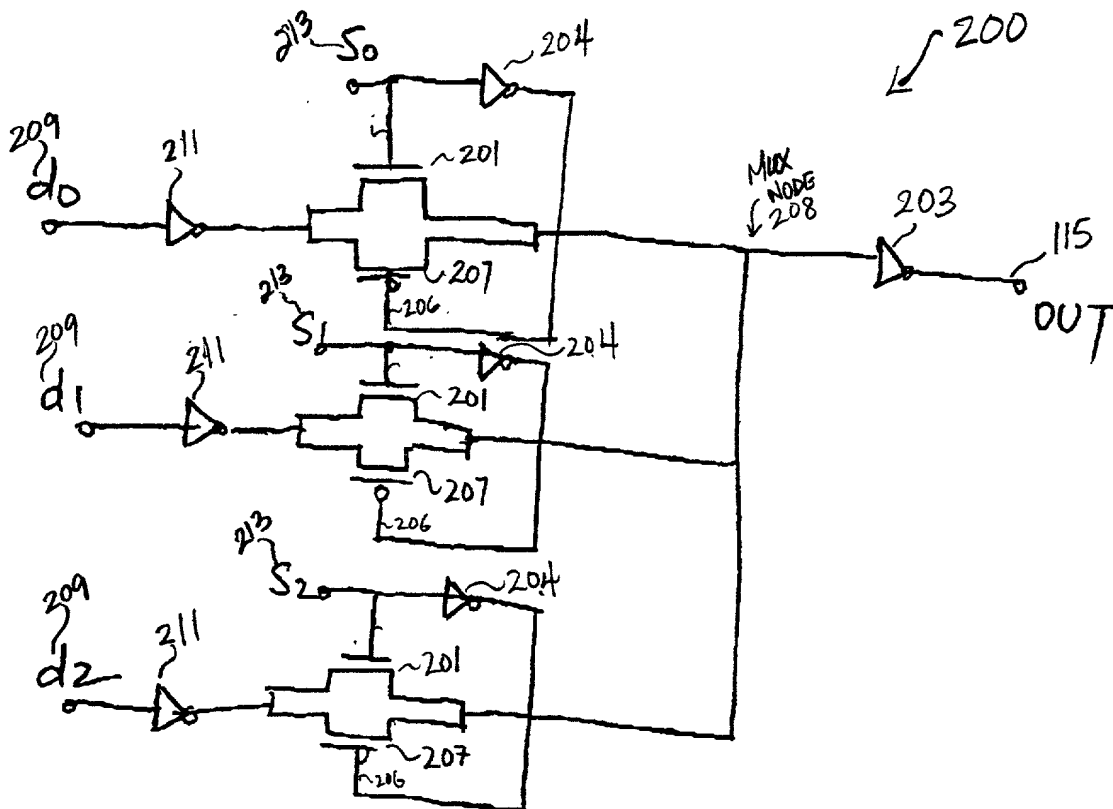


FIGURE 2



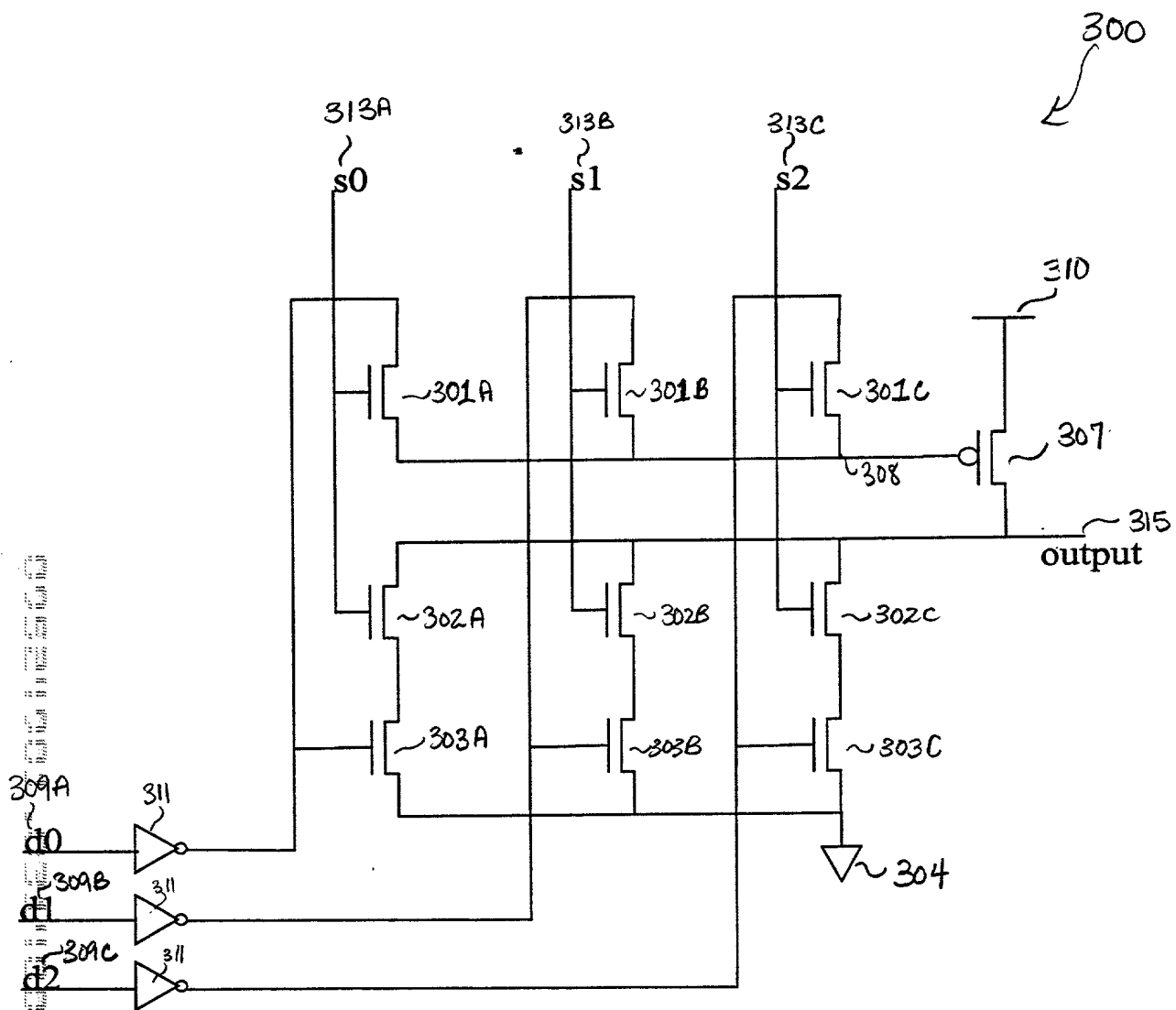


Figure 3.

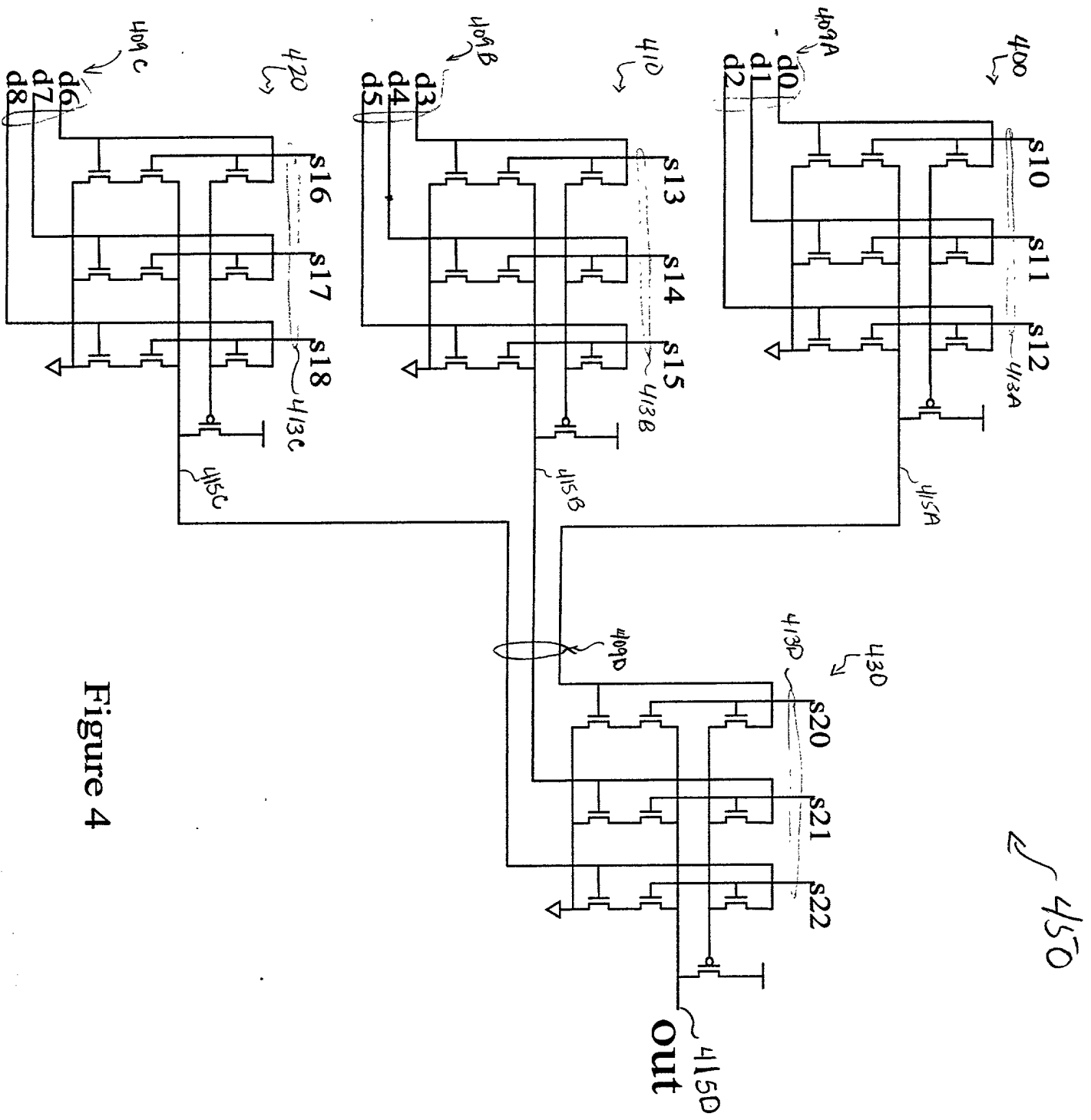


Figure 4

FIG. 4 is a schematic diagram of a crossbar array circuit, in accordance with an embodiment of the present invention.

PATENT APPLICATION

As a below named inventor, I hereby declare that:

My residence, post office address and citizenship are as stated below next to my name;

I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled

A HIGH SPEED, STATIC DIGITAL MULTIPLEXER

the specification of which (check one)

X is attached hereto.

___ was filed on _____
as Application Serial No. _____
and was amended on _____
(if applicable)

I hereby state that I have reviewed and understand the contents of the above identified specification, including the claims, as amended by any amendment referred to above.

I acknowledge the duty to disclose information which is material to the patentability of this application in accordance with Title 37, Code of Federal Regulations, §1.56.

I hereby claim foreign priority benefits under Title 35, United States Code, §119 of any foreign application(s) for patent or inventor's certificate listed below and have also identified below any foreign application for patent or inventor's certificate having a filing date before that of the application on which priority is claimed:

Prior Foreign Application(s):			Priority Claimed
_____ (Number)	_____ (Country)	_____ (Day/Month/Year)	___ Yes ___ No

I hereby claim the benefit under Title 35, United States Code, §120 of any United States application(s) listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States application in the manner provided by the first paragraph of Title 35, United States Code, §112, I acknowledge the duty to disclose information material to the patentability of this application as defined in Title 37, Code of Federal Regulations, §1.56 which occurred between the filing date of the prior application and the national or PCT international filing date of this application:

_____ (Application Serial #)	_____ (Filing Date)	_____ (Status)
---------------------------------	------------------------	-------------------

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or

imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

POWER OF ATTORNEY: As a named inventor, I hereby appoint the following attorneys and/or agents to prosecute this application and transact all business in the Patent and Trademark Office connected therewith.

John W. Henderson, Jr., Reg. No. 26,907; Thomas E. Tyson, Reg. No. 28,543; Robert M. Carwell, Reg. No. 28,499; Jeffrey S. LaBaw, Reg. No. 31,633; Douglas H. Lefevre, Reg. No. 26,193; Casimer K. Salys, Reg. No. 28,900; David A. Mims, Jr., Reg. No. 32,708; Volel Emile, Reg. No. 39,969; James H. Barksdale, Jr. Reg. No. 24,091; Anthony V. England, Reg. No. 35,129; Leslie A. Van Leeuwen, Reg. No. 42,196; Marilyn S. Dawkins, Reg. No. 31,140; Mark E. McBurney, Reg. No. 33114; Christopher A. Hughes, Reg. No. 26,914; Edward A. Pennington, Reg. No. 32,588; John E. Hoel, Reg. No. 26,279; Joseph C. Redmond, Jr., Reg. No. 18,753; Matthew S. Anderson, Reg. No. 39,093; Matthew W. Baca, Reg. No. 42,277; Michael R. Barré, Reg. No. 44,023; Max Ciccarella, Reg. No. 39,454; Andrew J. Dillon, Reg. No. 29,634; Justin M. Dillon, Reg. No. 42,486; John G. Graham, Reg. No. 19,563; Andrew M. Harris, Reg. No. 42,638; Steven Lin, Reg. No. 35,250; Richard N. McCain, Reg. No. 43,785; Jack V. Musgrove, Reg. No. 31,986; Antony P. Ng, Reg. No. 43,427; Michael E. Noe, Jr., Reg. No. 44,975; Brian F. Russell, Reg. No. 40,796; and Daniel E. Venglarik, Reg. No. 39,409.

Send correspondence to: Andrew J. Dillon, FELSMAN, BRADLEY, VADEN, GUNTER & DILLON, LLP, Suite 350 Lakewood on the Park, 7600B North Capital of Texas Highway, Austin, Texas 78731, and direct all telephone calls to Andrew J. Dillon, (512) 343-6116.

FULL NAME OF SECOND INVENTOR: JIEMING QI

INVENTORS SIGNATURE: *Jieming Qi* DATE: 3/6/00

RESIDENCE: 7913 Snook Hook Trail
Austin, Texas 78729

CITIZENSHIP: China

POST OFFICE ADDRESS: 7913 Snook Hook Trail
Austin, Texas 78729

FULL NAME OF SOLE OR FIRST INVENTOR: HUNG CAI NGO

INVENTORS SIGNATURE: *Hung Cai Ngo* DATE: 3/6/2000

RESIDENCE: 3609 Ruby Red Drive
Austin, Texas 78729

CITIZENSHIP: United States

POST OFFICE ADDRESS: 3609 Ruby Red Drive
Austin, Texas 78729